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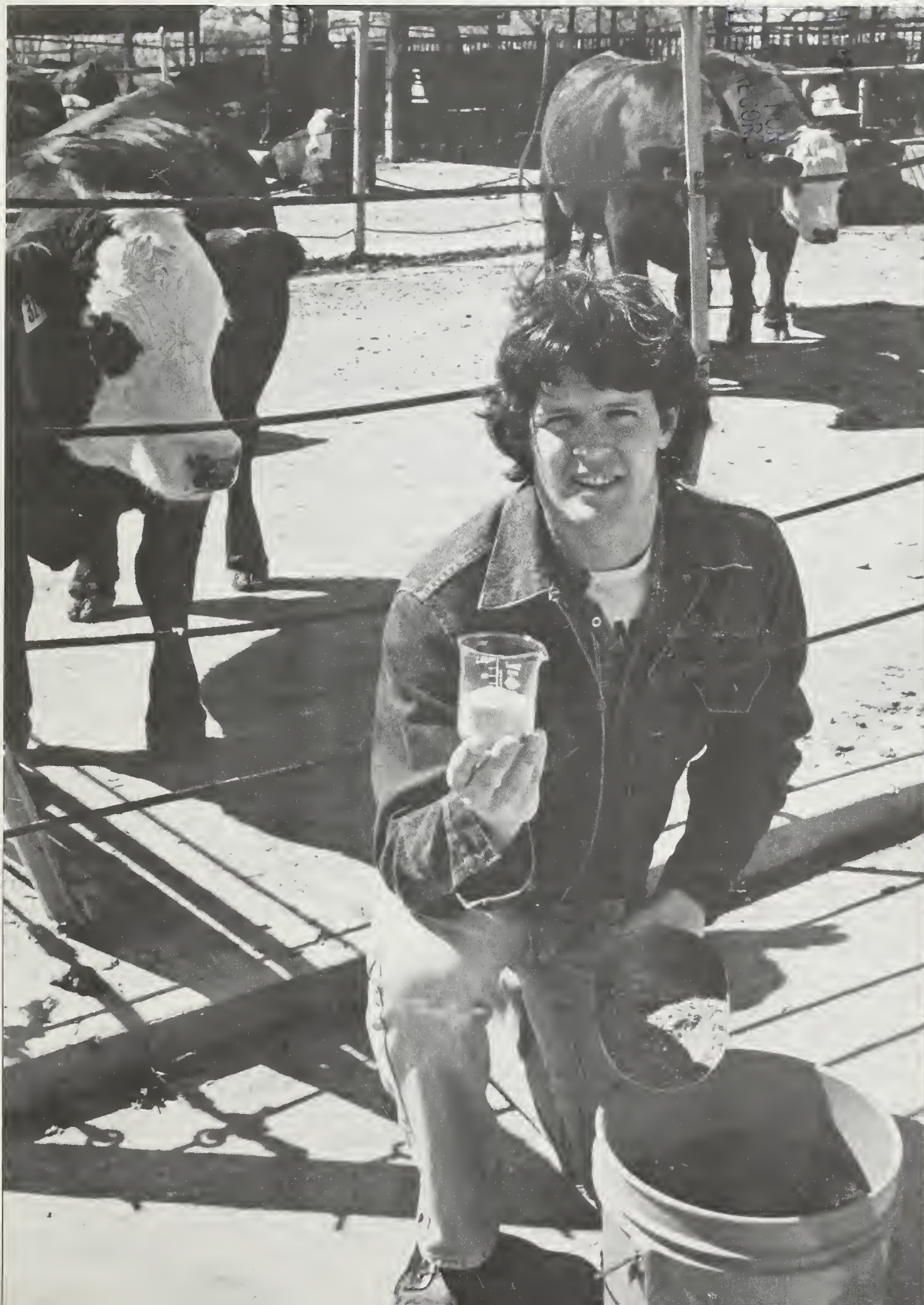
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# Agricultural Research

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## Basic Research: Replenishing the Reservoir

The mere mention of the word "drought" brings grim pictures to mind: parched crops; sun-baked soil; depleted water reservoirs. Pictures like these haunt farmers every year. When rain doesn't fall, productivity suffers.

However, lack of moisture is not the only kind of drought that threatens agricultural productivity. There is another scarcity faced by American farmers — one whose effects could be equally as disastrous, and certainly more prolonged. This other drought is in basic research — the study of the fundamental properties of life and matter.

Until recently, most of us haven't worried about our shrinking pool of basic knowledge. Americans have seen their agriculture become the most productive in the world. Production records have been set with such consistency that many of us take records for granted.

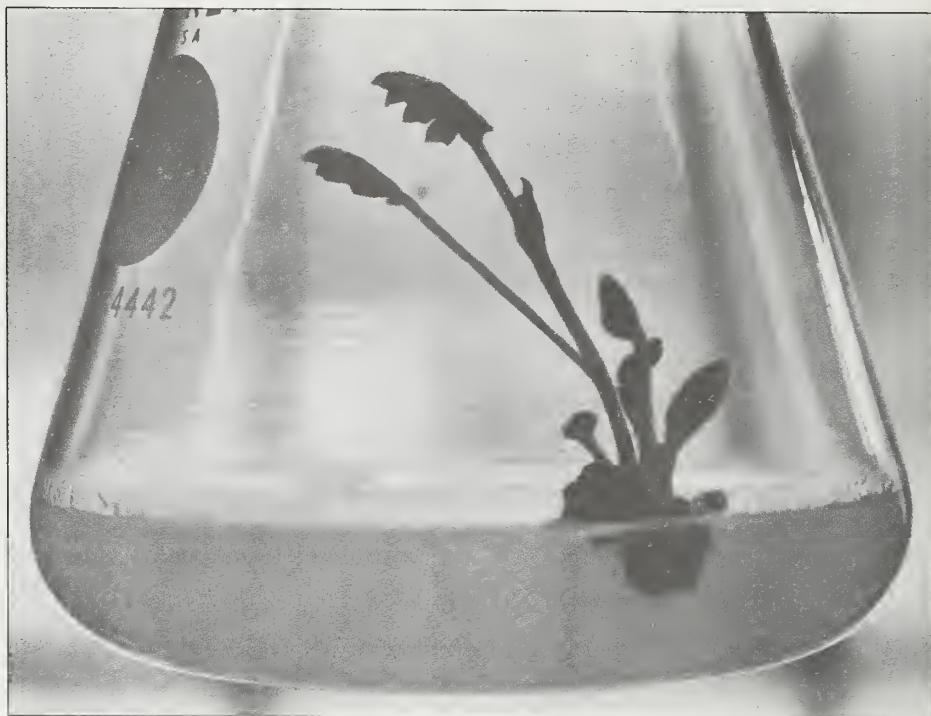
However, there are signs that the pool of knowledge from which this growth has been generated is being depleted. Agricultural productivity — the payoff on past investments in research — increased 2.1 percent per year between 1939 and 1965, but now is increasing at an annual rate of only 1.7 percent.

We reached our present level of productivity by manipulating plants and animals to improve their productive capabilities. Although these methods have served us well, our slowing productivity rates suggest that limits to such methods may now be in sight. It is time to renew and expand the basic knowledge that will generate new agricultural technologies.

There are, however, several characteristics of basic research that must be kept in mind.

*First*, basic research is a long-term, high-risk enterprise. It requires a continuous investment of time and money, and there may be no payback for many years.

For example, the attraction of male moths to female moths was noted several centuries ago. The USDA Bureau of Entomology investigated the female moth attractant early in this century, but the first attractant, or pheromone, was not chemically identified until 1959.



*Second*, seemingly esoteric work may have far-reaching effects. The gypsy moth pheromone was discovered by scientists interested in the sexual behavior of insects. However, their discovery enabled other scientists to manufacture synthetic pheromones — and resulted in a technology that today is an important part of our integrated pest management approach to the control of crop pests.

*Third*, work in one area may contribute to other areas of study. For example, in 1963 a USDA scientist investigating the chemical components of cow's milk discovered lactollin, a milk protein. This later was identified as the bovine equivalent of beta<sub>2</sub>-microglobulin. Lactollin, now is used in studies of how the human body responds to disease. (See article on page 4.)

*Fourth*, many important discoveries are accidental. Alexander Fleming, the discoverer of penicillin, was studying staphylococcal bacteria when he noticed that the fungus contaminating some of his culture plates was surrounded by a bacteria-free zone. (See article on page 14.)

Finally, costly technology may pay for itself by speeding up progress in research. One reason the pheromone studies were delayed was that half a million insects were needed at first in order to extract enough material for identification. Modern instruments for chromatography and mass spectrometry have cut that number to 100. The return on the investment that produced these techniques is shared by research in many areas.

If agriculture is to maintain and increase its productivity, we must replenish our reservoirs of basic knowledge. Private enterprise is reluctant to risk the uncertainties inherent in basic research. This means that publicly supported agricultural research must lead the advance on new frontiers of basic knowledge and innovative technology. Only then can the most disastrous drought of all be avoided.

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Cover: SEA researchers in Beltsville, Md., are studying the effects of various nutritional factors and growth promotants on weight gain and protein retention in steers. Dennis Hucht, biology laboratory technician, holds beaker of kiln dust, which has been added to the diet of steers in some experiments to determine its effect on weight gain (481W365-27a). Our article begins on page 10.

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## Beta<sub>2</sub>-Microglobulin: A Key to Understanding the Body's Defense Against Diseases?



Research currently underway on a protein found in cow's milk and human body fluids may lead to better understanding of how animals and humans fight disease. The protein, beta<sub>2</sub> - microglobulin, may also have potential as a marker for early detection of certain diseases.

Knowledge obtained in the beta<sub>2</sub> - microglobulin studies will be return on an investment in basic research that began 18 years ago with a study of the fundamental properties and components of milk.

In 1963, M. L. Groves, a SEA dairy scientist, and his colleagues at the Eastern Regional Research Center (ERRC) in Philadelphia, Pa., discovered a new protein in cow's milk. Named lactollin, meaning a proteinaceous substance derived from milk, it was isolated in a very pure form, crystallized, and characterized in terms of composition.

Although samples were made available to scientists who wished to conduct experiments with this new protein, no new information concerning lactollin, it turned out, would be forthcoming for many years.

"A discovery had been made, but its relevance had not yet been realized or appreciated," says Groves.

Then in 1968, two scientists from the Institute of Medical Chemistry in Sweden discovered beta<sub>2</sub>-microglobulin in the urine of cadmium-poisoned people. This protein received a great deal of attention from medical research scientists because of its relationship to proteins involved in the body's defense against disease.

Studies on beta<sub>2</sub>-microglobulin isolated from several mammalian species were reported in 1976. After reading those reports, Groves realized that in composition, beta<sub>2</sub>-microglobulin resembled the protein lactollin, which he had discovered 13 years earlier.

M. L. Groves, biochemist, isolates beta<sub>2</sub>-microglobulin—a protein found in cow's milk and body fluids—through column chromatography (381W278-29).

Futher research in collaboration with Rae Greenberg, dairy scientist at the ERRC Food Science Laboratory, established that lactollin was the bovine form of  $\beta_2$ -microglobulin. This discovery has led to a readily available supply of  $\beta_2$ -microglobulin that can easily be crystallized for futher examination. Bovine  $\beta_2$ -microglobulin is the only type that has been crystallized.

The relationship of  $\beta_2$ -microglobulin to the immunoglobulins and to cell-surface proteins suggests an important role for it in the body's disease-defense mechanism. Researchers at Rockefeller University in New York are conducting X-ray crystallographic studies on the bovine  $\beta_2$ -microglobulin to develop a three-dimensional picture of the substance for use in determining its function.

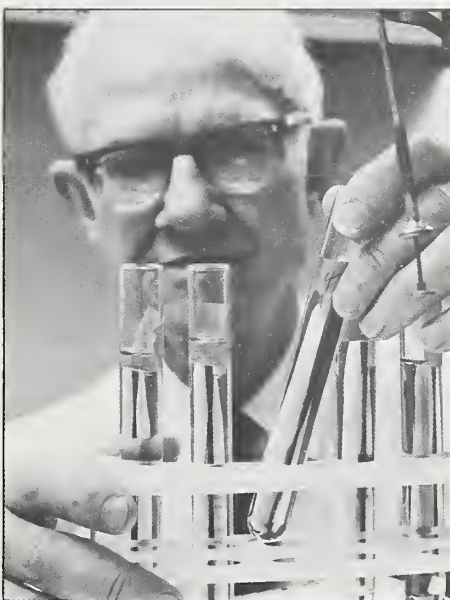
Researchers hope eventually to learn how certain cell-surface proteins recognize foreign substances in the body, the first step in a series of events leading to destruction of the invaders.

Scientists do know that  $\beta_2$ -microglobulin is present in elevated amounts in mammals with certain diseases. For example, in the urine of mammals with kidney damage it is secreted at levels 1,000 times normal. These findings suggest that the protein may have potential for early detection of certain diseases.

M. L. Groves and Rae Greenberg are located at the ERRC, 600 East Mermaid Lane, Philadelphia, PA 19118.—(By Laura Fox, SEA Information, Washington, D.C.)



Above: By injecting amino acids cleaved from  $\beta_2$ -microglobulin into a gas chromatograph, Rae Greenberg, biochemist, can identify the sequence of these amino acids along the protein molecule (381W278-18).



Left: After it has been isolated, Groves checks the  $\beta_2$ -microglobulin for purity by polyacrylamide disc gel electrophoresis (381W279-20a).

## Yellow Wilt— Preparing for a Sugarbeet Disease Invasion



**R**esearchers in North and South America are racing against the clock to develop sugarbeets that are resistant to a disease called yellow wilt.

Yellow wilt is currently confined to two South American countries—Chile and Argentina. If the disease accidentally enters the United States, this country's \$660 million sugarbeet industry would be severely damaged. Arizona and California fields would probably be the hardest hit.

Yellow wilt is caused by a disease organism that attacks cells of the whole sugarbeet plant. Symptoms of yellow wilt depend on many factors, including temperature and humidity. Under some conditions, plants wilt and die quickly; under other conditions, they turn yellow and die after several weeks.

"With modern transportation and the volume of traffic between South America and other beet-growing areas, yellow wilt's spread and establishment in other areas seems inevitable," said John O. Gaskill, project consultant for the Beet Sugar Development Foundation (BSDF) Fort Collins, Colo., and coordinator of yellow wilt-resistance breeding research. The Foundation, an association of U.S. and Canadian beet sugar companies and other organizations, is cooperating with SEA, Dutch and Chilean seed companies, and an Argentine experiment station in conducting that breeding project, which is funded by SEA through a cooperative agreement with BSDF.

Yellow wilt and the insect that carries the disease, a leafhopper, are not known to exist outside Chile and Argentina. However, two factors—similar weather and weeds that are excellent hosts for both the leafhopper and the disease organism that causes yellow wilt—exist in many areas of the world where beets are grown commercially.

Yellow wilt undoubtedly was one of the principal causes of the beet industry failure in Argentina early in the 1940's. The industry there has never recovered

A panoramic view of a sugarbeet field—part of the \$660 million industry that could be devastated by the invasion of yellow wilt disease. (Photo courtesy Grant Heilman)

from the disease invasion. Chile also has experienced problems with the disease ever since the sugarbeet industry began there in 1954.

"Don't look to pesticides to control the insect that carries yellow wilt as a way of minimizing disease losses. For satisfactory results, accurate insect surveillance and precise timing of insecticide applications, with respect to insect migrations, are a must," says Gaskill. "Consequently in Chile, control expenses have been high and effectiveness variable. Attempts to control yellow wilt by insecticides in Argentina have been unsuccessful."

Breeding resistance into sugarbeet appears to be the most effective and cheapest approach to combating yellow wilt. So far researchers have developed a level of resistance that is not high, but evidence strongly indicates that further progress can be made.

Under the direction of plant pathologist C.W. Bennett, formerly head of SEA's U.S. Agricultural Research Station, Salinas, Calif., more than 380 sugarbeet cultivars were evaluated for resistance to yellow wilt in Argentina and Chile between 1938 and 1969. None showed any appreciable resistance.

According to breeding records, most of the yellow wilt-resistant lines developed to date were derived from plants selected in open-pollinated, curly top-resistant USDA sugarbeet cultivars in Chile. However, the sources of pollen entering into the early reproductions are not known. The researchers suspect that wind-blown pollen from wild Chilean *Beta vulgaris* may have contributed resistance to the breeding lines. Such wild material was growing in Chile more than a century ago in areas where yellow wilt is currently prevalent. Studies now are under way to determine whether



Above: Gaskill removes seedlings from photo-thermal induction room. Beet seedlings are kept here for 90 days at 40 degrees Fahrenheit under 24 hours of light to induce production of flowering hormones. This procedure simulates winter conditions that cause hormone production (1080X1267-33).



Left: By importing South American sugarbeets that are highly resistant to yellow wilt, SEA researchers in California and Colorado can study yellow wilt resistance without bringing the disease into the country (1080X1270-1).

Yellow Wilt—  
Preparing for a Sugarbeet  
Disease Invasion



Above: John O. Gaskill, former head of SEA sugarbeet production research at Fort Collins, Colo., examines sugarbeet seedlings. Parents of these plants exhibited the highest level of yellow wilt resistance in South American field studies. These seedlings in turn will become parents of beets that will undergo further field testing (1080X1267-20).

such material is a valuable source of genes for resistance in the breeding program.

At the SEA Crops Research Laboratory, Fort Collins, Gaskill and SEA researchers make crosses between various cultivars considered promising for resistance and between such material and susceptible but otherwise superior cultivars. Seed resulting from this work is then sent to South America and grown under direct exposure to yellow wilt. Plants apparently outstanding in resistance are selected and permitted to reproduce. No living disease organism is brought into this country.

Seed of resistant breeding lines is multiplied at the SEA Salinas and Fort Collins labs for further evaluation, selection, and hybridization.

"The cultivars or breeding lines developed thus far represent a very significant advance from the zero level of resistance that existed when the yellow wilt-resistance breeding project began in 1967," says John S. McFarlane, SEA plant geneticist and director of the Salinas lab.

"Once we get an acceptable level of resistance built into beets, we will cross them with beets that have high yield, high sugar content, and several other desirable characteristics. The latter part will be easy compared to getting a desirable level of resistance to yellow wilt," says Richard J. Hecker, SEA plant geneticist and research leader at Fort Collins.

Other crops in the same scientific classification as sugarbeet (*Beta vulgaris*), such as Swiss chard, table beet, and fodder beet, are also highly susceptible to yellow wilt.

Dr. McFarlane's address is U.S. Agricultural Research Station, 1636 E. Alisal St., P.O. Box 5098, Salinas, CA 93901. Dr. Hecker's address is Crops Research Laboratory, Colorado State University, Fort Collins, CO 80523.

## Cancer Eye Linked to Solar Activity?

If changes in the ozone layer surrounding the earth should increase ultraviolet radiation, more cases of cancer eye in susceptible cattle and more severe episodes of the disease could be expected.

Research at the National Animal Disease Center, Ames, Iowa, supporting this conclusion also strengthens the belief of scientists that exposure of such cattle to ultraviolet-beta radiation may induce the disease, also known as bovine ocular squamous carcinoma or epithelioma.

A team of SEA scientists produced anatomic changes and lesions typical of early cancer eye in susceptible cattle by exposing the cattle to controlled doses of ultraviolet-beta radiation from sun lamps.

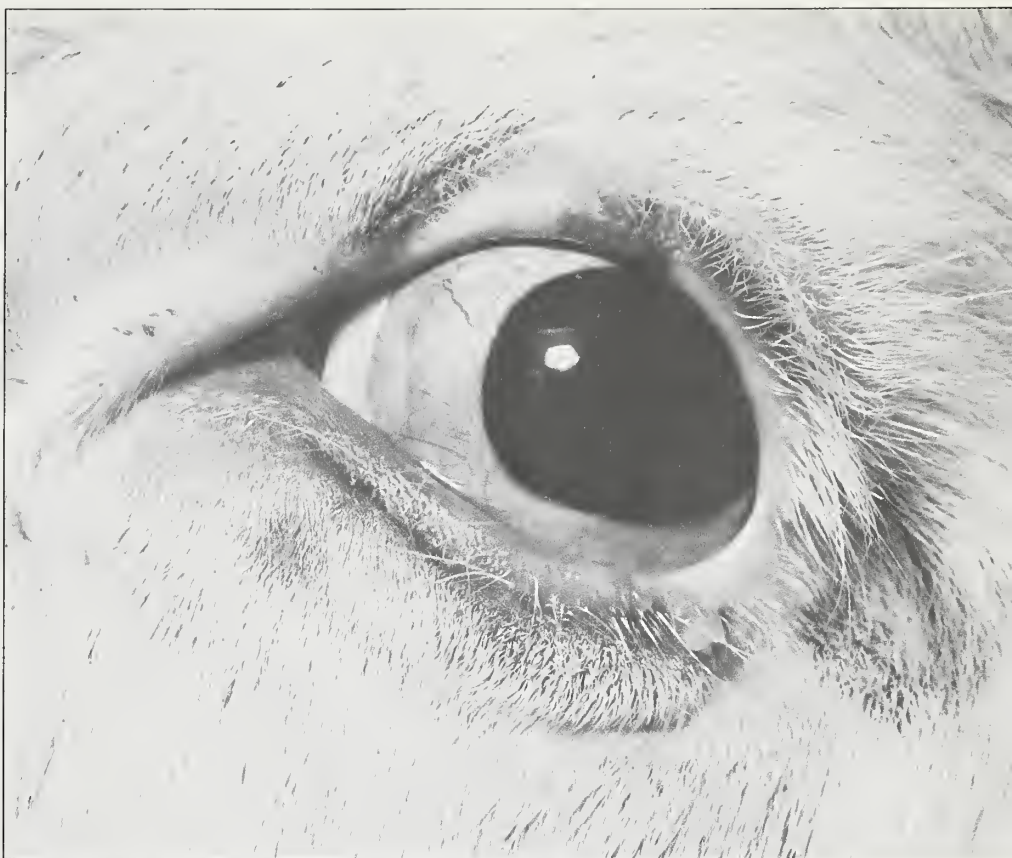
The researchers also suggest an association between solar activity and numbers of cattle condemned because of cancer eye at USDA-inspected slaughter plants between 1950 and 1976.

Cancer eye has been reported in almost every breed of cattle, but most frequently in Herefords. Within the Hereford breed, cattle lacking any pigment around and in the eye—a genetically controlled trait—are most susceptible.

Herefords lacking pigment around the eyes, from a line with a history of cancer eye, were used in the study by veterinary medical officers Kenneth E. Kopecky, George W. Pugh, Jr., David E. Hughes, and Norman F. Cheville, and statistician Gordon D. Booth.

For 22 months, first for 7 minutes daily and then for periods gradually increasing to 180 minutes daily, the cattle were stanchioned facing ultraviolet-beta radiation from FS-40 lamps. During the total exposure of 1,500 hours, the lamps were filtered to absorb wavelengths below 285 nanometers, so that the radiation resembled natural ultraviolet-beta radiation.

Three of the four animals exposed to ultraviolet radiation developed lesions typical of early stages of cancer eye. The fourth animal had



Does increased exposure to ultraviolet radiation cause cancer eye? SEA researchers are studying Herefords susceptible to the disease to find out (481W365-12).

deep-set eyes under a prominent crest, which apparently protected its eyes. The scientists ruled out pinkeye and cytopathic herpesvirus infection as probable causes of damage to the animals' eyes.

A 1950-76 survey of condemnations for cancer eye by federal meat inspectors also shows indirect evidence linking cattle exposure to ultraviolet-beta radiation with development of this disease, according to Kopecky.

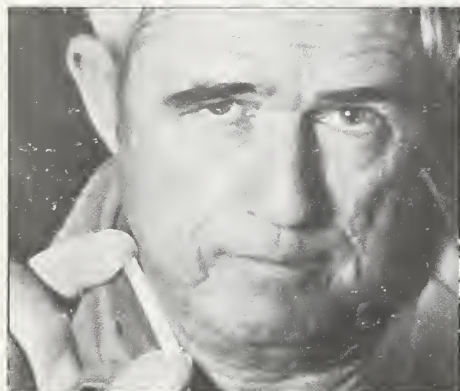
Taking into account the annual increase in number of cattle slaughtered, the researchers found that the percentage of annual condemnations for cancer eye doubled over the 16-year period. Greater awareness of the disease by inspectors of what is now USDA's Food Quality and Safety Service may have been a factor in this increase. But Kopecky believes the incidence of the disease also rose.

The researchers plotted annual condemnations, adjusted for numbers slaughtered, on a graph. Then they plotted solar activity—shifting solar activity forward 5 years on the graph to account for apparent delay in development of cancer eye after exposure. Annual cancer eye condemnations and annual solar activity both peaked on the graph near the same times—about 1960-62 and again about 1970-74.

The Environmental Protection Agency partially funded this study.

Dr. Kenneth E. Kopecky and associates are located at the National Animal Disease Center, P.O. Box 70, Ames, IA 50010.—(By Walter Martin, SEA, Peoria, Ill.)

# Steers Implanted with Synovex-S Gain More Protein



Top: Stroud injects Synovex-S implant into steer's ear. Kathy McKim, veterinary aide, assists him (481W366-12)

Above: Synovex-S implant, shown by Ben Stroud, veterinarian at the Ruminant Nutrition Laboratory, Beltsville, Md., can increase a steer's weight gain and protein deposition by 25 percent (481W364-12).



Above: In the lab, Hucht weighs tissue sample for chemical analysis that will determine the implant's effect on the composition of tissue deposition (481W366-1a).

Steers implanted with the estrogen Synovex-S gained 25 percent more weight and 25 percent more protein than steers without this implant, says SEA animal scientist Theron S. Rumsey, Ruminant Nutrition Laboratory, Beltsville, Md. Rumsey also tested the effect of adding cement kiln dust—a byproduct of cement—to the steers' diet.

All steers were fed a 50 percent concentrate (primarily corn and soybean) diet. Although Synovex-implanted steers fed 2.5 percent kiln dust gained the most weight, the kiln dust did not play a prominent role. Synovex-implanted steers fed kiln dust gained a daily average of 3.02 pounds (1.36 kilograms), while those with only the hormone implants gained 2.91 pounds (1.31 kg) a day. Nonimplanted steers fed the kiln dust and control steers (no implant, no kiln dust) gained similarly, 2.42 pounds (1.10 kg) a day.

These findings are in contrast to recent work by William Wheeler, a SEA animal scientist at the U.S. Meat Animal Research Center, Clay Center, Nebr. Wheeler found that steers fed a diet with 3.5 percent kiln dust gained 28 percent more weight, and pound for pound required 21 percent less feed, than steers on a 53 percent hay diet without kiln dust. Further study with kiln dust is needed to determine its role in weight gain and to evaluate the different results.

"In our research, the kiln dust seemed to have little effect on weight gain. The Synovex-implanted steers gained weight faster and ate less feed per pound of gain. Perhaps even more important than the weight gain, steers with implants deposited 20 to 25 percent more protein than those without implants," says Rumsey.

Synovex-S has been approved by the Food and Drug Administration for use in cattle, but must be implanted at least 60 days before animals are slaughtered. Steers with these implants convert feed to beef 15 percent more efficiently than those without the Synovex treatment and have higher carcass retention of protein, fat, and minerals.

Dr. Theron S. Rumsey is located at the Animal Science Institute, Room 132, Bldg. 200, BARC-East, Beltsville, MD 20705.—(By Darien Small, SEA Beltsville, Md.)

## Reduced Dosage of Brucellosis Vaccine

Adequate protection against brucellosis in cattle, a disease causing abortion and reduced milk production, can be produced with a substantially reduced dosage of Strain 19 vaccine, SEA research indicates.

Billy L. Deyoe, SEA veterinary medical officer, found that vaccine doses of 100 million to 10 billion *Brucella abortus* bacteria provided sufficient protection against brucellosis.

Based on results of the SEA studies the Department's Animal and Plant Health Inspection Service and state animal-health regulatory agencies are altering their regulations to permit vaccination with 300 million to 3 billion bacteria instead of the average of 90 billion used previously. Bacteria from the naturally attenuated or weakened Strain 19 are used in the vaccine.

Deyoe, veterinary medical officer Terrance A. Dorsey, and technicians Kathryn A. Meredith and Linda A. Garrett compared results with dosages of 10 million, 100 million, 1 billion, 10 billion, and the former standard rate of 90 billion bacteria. They vaccinated 106 beef heifers as yearlings and 106 Angus-Hereford heifers as 4- to 6-month-old calves.

After vaccination, the heifers were tested for false positive reactions in diagnostic tests for brucellosis. False positive reactions may cause vaccinated animals to be classified as possibly diseased, which may lead to their slaughter.

The intensity and duration of false positive reactions were directly related to vaccine dosage levels, Deyoe says.

In heifers vaccinated as yearlings, the 10-million and 100-million dosages produced false positive reactions at 8 weeks after vaccination and thereafter, but the 1-, 10-, and 90-billion dosages produced consistent or intermittent reactions lasting until immunity was challenged at 8 months after vaccination.

In heifers vaccinated as calves, only 10- and 90-billion dosages produced false positive reactions lasting as long as



Private veterinarian gives calf reduced dosage of Strain 19 vaccine against brucellosis, a disease that causes abortion and reduced milk production in cattle (475R471-29).

12 weeks after vaccination, Deyoe says. All of the heifers vaccinated as calves tested negative when immunity was challenged at 15 months after vaccination.

The heifers' immunity to brucellosis was challenged by inoculating the heifers with virulent *B. abortus* bacteria.

Levels of immunity produced by the various vaccine dosages differed according to the age of the heifers at vaccination, the researchers found.

In yearling heifers, all vaccine dosages produced significant and indistinguishable levels of immunity. In heifers vaccinated as calves, higher dosages produced higher levels of immunity. The 90-billion and 10-billion dosages gave maximum immunity, the 1-billion and 100-million dosages gave adequate immunity, and the 10-million dosage produced noticeable but less than adequate immunity.

Deyoe says that ideally, different dosages should be given to calves and to yearlings and older animals. Practical considerations may, however, dictate a compromise intermediate dosage for all ages.

Dr. Billy L. Deyoe and associates are located at the National Animal Disease Center, P.O. Box 70, Ames, IA 50010.

# Controlling Overwintering Pink Bollworm Populations

In their efforts to control pink bollworm, researchers and growers have for years been experimenting with methods of eliminating late-season, nonproductive green bolls from cotton plants.

These green bolls add nothing to cotton yields but harbor the larval stage of the pink bollworm, one of the most destructive pests of cotton in the Southwest.

The shortening days and lowering temperatures of the approaching winter trigger a response in the larvae, and they eat their way out of the green bolls, drop to the ground, burrow into the soil, and go into hibernation—called diapause. In the spring they emerge in great numbers to start their life cycle over again in the newly planted fields.

By eliminating the late-season green bolls as a food source for larvae, a great percentage of the overwinter population could be eliminated. Development of green bolls can be prevented by two methods: cutting off the late irrigations to slow down the vegetative growth of plants and treating plants with growth regulators to prevent the formation of new bolls.

Field tests in Arizona and California have shown that chemical termination with growth regulators can reduce the number of green bolls at harvest by 95 percent, without affecting yield and quality of cotton, and can reduce the number of diapause larvae in the soil by 90 percent. In combination with growth regulators, proper timing of the last irrigation can enhance those reductions, says Louis A. Bariola, SEA entomologist.

Bariola, along with Thomas J. Henneberry, entomologist, and David L. Kittock, agronomist (now retired), recently completed a 3-year study in Arizona combining the two methods.



In the first year of the study, five dates for the last irrigations were tested. Then, after 7 to 9 days, growth of the plants was chemically terminated (the chemical used is not registered under FIFRA as amended) in half of the plots; the other plots (the controls) were not treated. Along with the growth regulator, the researchers applied chlorflurenol, a chemical that prolongs the effects of growth regulators.

After harvest, larvae in diapause were counted in samples of soil, and number per acre were calculated. For the first

year of study, the researchers found the following numbers of diapause larvae:

Date of last irrigation	Treated	Control
July 26	0	1089
Aug. 10	0	2178
Aug. 24	0	8172
Sept. 12	2178	0
Sept. 27	2178	6534

The inconsistent data for the plot last irrigated on Sept. 12 indicated that the soil sample in which larvae were counted was not representative of the plot. Generally, no larvae were found in the soil of plots that were treated with growth regulators and were not irrigated after mid-August.

## New Pima Lines May Improve Cotton Crosses



Insect control was better in some years than in others. In the second year of the study, when the last irrigation was on July 24 (no chlorflurenol was used with the growth regulators) and when about half an inch of rain fell in mid-September, the estimated number of diapause larvae in the soil after harvest was about 1,000 per acre.

"That finding illustrates one of the possible difficulties of depending totally upon irrigation cut-off for early cotton terminations," Bariola says. "Finding so many diapause larvae in the soil at that time was a result of cotton regrowth that occurred due to early treatment, absence of chlorflurenol, and unseasonal rainfall," he adds.

At present, control of pink bollworm depends upon the use of insecticides. In the United States, about 50 percent of all agricultural insecticides are used on cotton. A large proportion of those insecticides is for control of pink bollworm and boll weevil and costs growers \$50 to \$75 million annually. Even so, losses to growers through boll and square damage by the two insects still amount to \$130 to \$230 million each year. Furthermore, insecticides applied to control pink bollworm and boll weevil destroy natural predators of other insect pests of cotton and leave the cotton vulnerable to those insects.

During normal years, cotton farmers may apply pesticides 15 times at a cost of from \$5 to \$7 per acre each time. If late-fruited cotton were terminated, the first application in the next season could be delayed until the population of pink bollworm reached damaging levels—some 30 to 60 days. Such delays in insecticide applications for pink bollworm could amount to savings of \$2 to \$4 million per year.

The combined treatment for termination of late-fruited cotton also might help control overwintering larvae of boll weevil. Bariola warns, however, that only tests in southeastern cotton-producing areas, where damage from boll weevil is severe, would show whether the combined treatment would be effective for boll weevil.

Dr. Louis A. Bariola is stationed at SEA's Western Cotton Research Laboratory, 4135 E. Broadway Rd., Phoenix, AZ 85040.

Two new early maturing, short-statured lines of Pima cotton (79-103 and 79-106) may help solve the persistent problem of excessive vegetative growth in Upland-Pima cotton crosses.

Crosses between Upland and Pima cottons are examples of interspecific hybridization. Cotton breeders are interested in such crosses because the resulting hybrid vigor often leads to improved yields.

Carl V. Feaster and Edgar L. Turcotte, SEA agronomist and geneticist respectively, developed the lines at the Cotton Research Center, University of Arizona, Phoenix. The scientists say, "In addition to the early maturity and short stature, these strains retain their short stature over a range of environments. Using these lines for interspecific hybrids will likely reduce the problem of excessive vegetative growth in the hybrid."

Both 79-103 and 79-106 are selections from crosses of experimental Pima strains. The new lines mature about 2 weeks earlier than Pima S-5, the current commercial Pima variety. The high degree of height stability of these lines increases the probability that excessive vegetative growth will be reduced when the new lines are crossed with Upland cottons.

Lint yields from 79-103 and 79-106 averaged 4 and 9 percent, respectively, higher than those of Pima S-5 in tests conducted at Phoenix and Safford, Ariz. In other studies the fiber properties of the new lines were found to be equal or superior to those of Pima S-5.

Feaster reports that several public and private cotton breeders have requested seed of these strains for inclusion in their hybrid cotton improvement programs.

Breeders and geneticists may request limited amounts of seed by writing Carl V. Feaster, USDA, Science and Education Administration, University of Arizona Cotton Research Center, 4207 E. Broadway Rd., Phoenix, AZ 85040.—(By Paul Dean, SEA, Oakland, Calif.)

## Penicillin — Always the Struggle to Get Enough



Above: A wounded World War II soldier receives a shot of penicillin at an Army hospital on the European front (PN-6816).

Opposite page: Donald T. Wicklow, Thomas G. Pridham, and Kenneth B. Raper check a freeze-dried preparation of living, penicillin-producing mold cells against the accessions record initiated at the Northern Laboratory by Raper and still used by Wicklow. Wicklow, Raper's student at the University of Wisconsin, now occupies his mentor's former laboratory at the Northern Center. Pridham heads the NRRL Culture Collection, a position once held by Raper (980X117319a).

**The successful commercial production of penicillin . . . opened the door to the antibiotic age . . . (George E. Ward, *Advances in Applied Microbiology*).**

On the other side of that door is a story of unrelenting struggle and cooperation among researchers on both sides of the Atlantic during World War II to find ways to mass produce enough penicillin for the sick and wounded. The bombings, supply shortages, and overburdened industry in England spurred scientists there to seek aid in the United States. They were referred to U.S. scientists at the USDA Northern Regional Research Center at Peoria, Ill., in 1941.

Unpublished files of declassified correspondence and reports document the progress and illustrate the intensity of their struggle to meet the unceasing demands for the antibiotic. These files were kept at the Center until their transfer to the National Archives in Washington, D.C., on September 8, 1980. The transfer was part of the dedication of a historical marker at the Center by officials of the American Institute of the History of Pharmacy and the Illinois Pharmacists Association.

### *Background*

Alexander Fleming discovered penicillin in 1928 at St. Mary's Hospital in London when he noticed that a contaminating mold was destroying staphylococcus bacteria in a culture. USDA scientist Charles Thom, Bureau of Plant Industry, Beltsville, Md., identified the mold in 1930. In 1939, the year the War began, five medical scientists (including Norman G. Heatley and Howard W. Florey) at the Sir William Dunn School of Pathology, Oxford University, developed methods for growing the mold in surface cultures and for extracting and concentrating penicillin. In surface cultures, microorganisms grow on the surface of a liquid nutrient, usually in shallow pans or at the bottoms of flasks.

Further research demonstrated the effectiveness of penicillin as an antibiotic in treating patients. USDA scientists had developed aluminum rotary fermentors in which pressure and agitation mixed sterile air with the microorganisms and liquid nutrients. This technique provided oxygen to growing cells and led to fermentations throughout solutions in 1,000-gallon tanks, instead of only on the surfaces of liquid in the shallow pans used in surface fermentation.

#### The Files

The penicillin files begin with a telegram to Orville E. May, the director of the Northern Regional Research Laboratory, on July 9, 1941. Percy A. Wells, a USDA administrator, set tenor and tempo for what was to become a 5-year effort: "... Heatley and Florey of Oxford, England, here to investigate pilot scale production of bacteriostatic material from Fleming's *Penicillium* in connection with medical defense plans. Can you arrange immediately for shallow pan set up to establish laboratory results . . . ?"

This was about 5 months before Pearl Harbor and near the end of the Luftwaffe fire-bombing in London.

By October 1942, Robert D. Coghill, then fermentation chief at the Northern Laboratory could write to Florey "... we are now obtaining as high as 90 units per cc. in submerged cultures and as high as 150 units per cc. in surface cultures . . ."

Florey replied, congratulating Coghill "on such a splendid result. I hope you can carry it on to a large scale quite soon.

"We are obtaining quite astonishing results on staphylococcal cases . . . but have had to desist now from lack of material . . . . Staphylococcal infections require about 1,500,000 units or a little more to cure them . . . you can have no doubt whatever that the stuff works . . . .

"We sent 5 gms. of stuff out to the Middle East . . . used, so far as we have been informed, very successfully . . .

"As always, the great struggle is to get enough stuff and that, of course, considerably hampers our progress," wrote Florey.



Florey's letter is dated November 4, 1942, the same day that British Field Marshal Montgomery broke through at El Alamein and German Field Marshal Rommel ordered a general retreat from Egypt.

By the following May, Coghill was reporting that 17 companies were working on penicillin. "I do not believe that any one or two companies can possibly make the amount of penicillin that will be necessary," he wrote in one letter. "... every possible step should be taken to encourage anyone who will make a try at it."

He wrote to Florey "... looks now as though we shall be making at least 1,000,000,000 units per week."

In July, the invasion of Sicily began.

On July 23, 1943, A. N. Richards, chairman of the Committee on Medical Research in the Office of Scientific Research and Development, wrote to H. T. Herrick, who succeeded May as Northern Laboratory director, "The demands of Army and Navy were so great

during July that civilian clinical investigation came almost to a standstill."

About 2 weeks after V-J Day, 1945, Cogill wrote an industrial colleague, "We have discontinued our work on penicillin . . . the whole problem has lost any semblance of urgency . . . ." On October 10, he wrote Vannevar Bush, director of the Office of Scientific Research and Development, "This letter is to inform you that I am resigning my position at this laboratory as of October 31."

Twenty-five years later in 1970, George E Ward, a member of the USDA research team wrote, in *Advances in Applied Microbiology*: "Hundreds of new antibiotics have been discovered . . . about 20 have had sufficient merit to justify their industrial production . . . . Corn steep water is used in most media and submerged culture methods similar to those developed for penicillin are usually employed."

The door to the antibiotic age had opened.



## Agrisearch Notes

**"Terbar" System Conserves Soil and Water.** "Terbar"—that's what SEA agricultural engineer D. W. Fryrear calls a miniridge terrace topped with a wind barrier of perennial grass. This terrace-barrier combination consists of perennial grasses planted on a steep, narrow ridge 12 to 14 inches high and 6 feet wide. This ridge tops a terrace 5 inches high and 12 feet wide. The terrace conserves water on sandy, dryland soils where rain is scarce but intense, while the grass barrier reduces wind erosion.

The terbar system is superior to the terraces now being used—an annual strip of winter wheat or rye on the ridge of a much wider terrace. The higher, narrower terbar ridge increases the height of the perennial grass barrier, thus increasing its effectiveness in preventing wind erosion. In addition, the barrier's root system holds the ridge's soil together.

Since the terbar is only one-fourth as wide as conventional terraces, the farmer can devote more land to cash crops. And the grass barrier provides a habitat for wildlife, as well as beneficial insects.

Another advantage of terbars over terraces is that they are cheaper to

construct or to level and can easily be rebuilt to accommodate changes in row patterns and farming equipment. Their smaller ridge uses only one-half the volume of soil that the conventional terrace uses.

Finally, the system works. "A terbar system," says Fryrear, "held all the water from a 7 inch rainstorm on land with a 3 percent slope. None of the ridges failed and all the water infiltrated into the soil within 24 hours."

For maximum effectiveness, Fryrear explains, the terbar system should be used in combination with surface mulching, contour furrows, and furrow damming. He is now testing several grasses to determine their suitability for growth and for controlling weeds.

D. W. Fryrear works at the U.S. Big Spring Field Station, P.O. Box 909, Big Spring, TX 79720.—(By Bennett Carriere, SEA, New Orleans, La.)

**Flexcrop—Reducing Crop Failure Risk.** A SEA researcher has helped design a computer program called FLEXCROP to assist in reducing the risk of crop failure when dryland fields are recropped to spring grains or safflower.

The FLEXCROP program recommends management practices and predicts the yields a grower can expect using these practices for a given crop under specific field conditions. Already in operation and available for grower use through county Extension agents in

Montana, FLEXCROP predictions have been accurate within 5 to 10 percent of actual yields.

Recropped yields have generally been slightly lower than fallow yields, but by reducing the risks of crop failure and boosting production, FLEXCROP may reverse this trend and encourage more growers to recrop. Cropping the land every year not only increases total farm yields, but also is an effective way to control saline seeps and soil erosion.

To obtain FLEXCROP recommendations and predictions, growers provide responses to questions asked by a computer. FLEXCROP answers are based on research studies that have shown grain yields to be a product of water supply, crop, variety, weeds, fertility, planting date, and rotation.

The FLEXCROP program was created by SEA soil scientist Ardell D. Halvorson, Sidney, Mont., and Paul O. Kreage, soil scientist at the Montana State University, Bozeman.

Halvorson says that even though FLEXCROP was designed for Montana producers, the program can be extended to other states. FLEXCROP is part of the AGNET system, an agricultural computer network.

Dr. Halvorson is located at the Northern Plains Soil and Water Research Center, P.O. Box 1109, Sidney, MT 59270.